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AIR TRAFFIC CONTROL

Evolution and Status of FAA's Automation Program

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Mr. Chairman and Members of the Subcommittee:

We are pleased to be here today to discuss the air traffic control (ATC) automation program of the Federal Aviation Administration (FAA). Automation and other functional areas such as communications, navigation, and surveillance are the main elements of FAA's overall plan for modernizing the air traffic control system. The automation program, which began in the early 1980s, involves FAA's acquisition of modern workstations and computers that process radar and flight data for controllers' use.

Because of severe cost, schedule, and technical problems, FAA restructured the automation program in 1994. The Advanced Automation System (AAS) project, divided into 5 separate segments, was the centerpiece of the program before its 1994 restructuring. In 1983, FAA estimated the cost to develop AAS to be $2.5 billion and completion was scheduled for 1996. When International Business Machines (IBM) was awarded a development contract in 1988, after a 4-year design competition, FAA estimated the project would cost $4.8 billion and be completed in 1998. By 1994, when FAA restructured the automation program, FAA estimated the cost to develop AAS to be as much as $7.6 billion with completion as late as 2003.

As part of the restructured program, FAA is undertaking major acquisitions for two segments of AAS—the Display System Replacement (DSR) and Standard Terminal Automation Replacement System (STARS). FAA estimates that these acquisitions will each cost about $1 billion to develop and will be completed by 2000 and 2005, respectively. FAA will also have to undertake other major acquisitions to provide all needed capabilities that had been promised under AAS.

Our testimony today, as requested by your Subcommittee, will focus on (1) how the automation program has evolved from the initial program to the current one, (2) to what extent FAA has had to implement costly interim projects to sustain the older equipment, and (3) whether the ongoing acquisitions are achieving their cost and schedule goals.

In summary

- In the 1994 restructuring, FAA cancelled segments of its initial automation program, scaled back others, and ordered the development of less costly alternatives. FAA still plans to replace the aging equipment that is increasingly difficult to maintain and to provide a basis for adding new

capabilities at a later date. One of the cancelled segments from the initial program would have addressed hardware maintenance problems that are now emerging with the mainframe computer—referred to as the Host—at FAA's facilities that control air traffic at higher altitudes. The agency expects to incur costs of about $160 million during fiscal years 1998 and 1999 to replace the mainframe computer hardware.

- As a result of the longstanding history of schedule delays in the automation program, FAA has added four interim projects—costing about $655 million—to sustain and enhance current automated equipment. Almost all of FAA's facilities that control air traffic at lower altitudes near airports will be upgraded through these interim projects.
- FAA has had mixed results in achieving its cost and schedule goals for the two major ongoing acquisitions in its restructured automation program. The Display System Replacement is within budget and on schedule. However, the Standard Terminal Automated Replacement System will likely have schedule delays of at least 6 months largely because software development has taken longer than expected and the agency and the contractor lack sufficient time to perform needed testing.

Automation Program Has Undergone Substantial Change

The evolution of FAA's automation program has involved changes in both the program's structure and requirements.

Changes in Program Structure

The centerpiece of FAA's automation program before its 1994 restructuring was the Advanced Automation System (AAS) project. Divided into 5 separate segments, AAS was designed to provide new work stations for controllers and related computer hardware and software that process radar and flight data for controllers' use. It was also designed to make possible the consolidation of more than 200 air route traffic control (en route) centers and terminal radar approach control (TRACON) facilities at 23 locations.[1]

[1]FAA uses three types of facilities to control traffic. Airport towers direct aircraft on the ground, before landing, and after takeoff within about 5 nautical miles from the airport and about 3,000 feet above the airport. Terminal radar approach control (TRACON) facilities sequence and separate aircraft as they approach and leave airports, beginning about 5 nautical miles and ending about 50 nautical miles from the airport and generally up to 10,000 feet above the ground. Air route traffic control centers, called en route centers, control planes in transit and during approaches to some airports. Most of the en route centers' controlled airspace extends above 18,000 feet for commercial aircraft. En route centers also handle lower altitudes when dealing directly with a tower, or when agreed upon with a terminal facility.

By May 1994, when FAA restructured the automation program, the agency had spent an estimated $2.6 billion on AAS. Our analysis of FAA data found that the restructured program was able to salvage about $1.1 billion in AAS-developed laboratory facilities and computer hardware and software. The balance—$1.5 billion—was wasted because the remaining equipment and work did not contribute to follow-on projects. (See app. I for more detailed information.)

The 1994 restructuring affected four of the five AAS segments. One segment was scaled back and renamed the Display System Replacement (DSR) project. Another was cancelled and replaced by the Standard Terminal Automation Replacement System (STARS) project. A third segment was scaled back and eventually cancelled. A fourth was cancelled and has yet to be replaced. The unaffected segment linked external systems, such as radars, to the en route centers' computers. This equipment—called the Peripheral Adapter Modular Replacement Item—was made fully operational in all of the en route centers by 1993.

- The segment of AAS called the Initial Sector Suite System was designed to replace controller workstations and supporting equipment at en route centers. This segment was scaled back to more closely replicate existing workstations and renamed the DSR project. The Lockheed-Martin Corporation is the prime contractor.[2]
- The segment of AAS called the Terminal Advanced Automation System was intended to replace controller workstations and supporting equipment in the TRACONS. This segment was cancelled in 1994. It was replaced by the STARS project. FAA signed the contract with Raytheon Corporation to acquire STARS in September 1996.
- The Tower Control Computer Complex segment would have installed new workstations for controllers in airport towers. The agency scaled back this segment in 1994 but cancelled it altogether in 1997 on cost-benefit grounds.
- The Area Control Computer Complex segment would have replaced the Host computer in each en route center.[3] These computers generate aircraft position and identification data for controllers' workstations. In 1994 FAA cancelled this segment of AAS and planned to replace the Host by 2005. However, a 1997 FAA analysis raised concerns about the maintainability of

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[2]Loral Corporation, having acquired IBM's division responsible for the AAS, was the prime contractor at the time of restructuring. Lockheed-Martin acquired Loral Corporation's division responsible for AAS.

[3]Also being considered was the replacement of the Direct Access Radar Channel at each en route center to provide a modern backup radar data-processing capability.

the current Host's hardware past the year 2001. In addition, FAA has concerns about the Host's ability to be Year 2000-compliant.[4] The agency estimates that it will cost about $160 million during fiscal years 1998 and 1999 to replace the Host hardware on an interim basis while continuing to use existing software for the foreseeable future. FAA is analyzing its alternatives and expects to make an investment decision in early March.

Changes in Requirements

When restructuring the program in 1994, FAA relaxed or eliminated six AAS requirements that were, in the agency's view, unnecessarily contributing to the project's cost growth. The first major AAS requirement FAA relaxed was the stipulation that the system could not malfunction more than 3 seconds per year. For the DSR and STARS projects, FAA relaxed this "availability" requirement to no more than 5 minutes of malfunctions per year; this level still exceeds today's requirement of no more than 2 hours of malfunctions per year.

The second major AAS requirement relaxed by FAA was the need for a separate training system that fully replicates the control room environment found in today's en route centers and TRACONS. FAA established this requirement for a so-called "full fidelity stand-alone" training system so controllers could become certified without having to train on live systems. Because on-the-job training remains critical to the training process, FAA decided not to build a system that fully recreates the control room environment.

When FAA planned to consolidate more than 200 en route and TRACON facilities at 23 locations, the agency established the requirement for an "integrated" backup capability to ensure that if any of the 23 facilities were to experience a system failure, the remaining 22 could provide air traffic services for the affected facility. Having scrapped the consolidation plan, FAA decided to provide independent ("stand-alone") backup systems for each en route center and TRACON.

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[4]On January 1, 2000, computer systems worldwide could malfunction or produce inaccurate information simply because the century has changed. The problem is rooted in how dates are recorded and computed. For the past several decades, computer systems have typically used two digits to represent the year (e.g. "97" rather than "1997"). In such a format, 2000 is indistinguishable from 1900. Software and systems experts nationwide are concerned that this ambiguity could cause systems to malfunction in unforeseen ways or to fail completely.

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FAA reconsidered how flight data would be displayed and used by controllers.[5] FAA had planned to move from paper to electronic flight strips so the agency could more easily reconfigure airspace and spread out controller workload. For DSR and STARS, however, the agency retained the existing paper flight strip technology because electronic strips were too technically challenging and costly to develop.

FAA eliminated several AAS requirements:

- FAA had planned to replace existing single common consoles for TRACON with dual consoles to meet AAS' availability requirement that the system could not malfunction more than 3 seconds per year and to present electronic flight strips. However, FAA decided to ease the availability requirement for STARS to no more than 5 minutes of malfunctions per year and not use electronic flight strips. As a result, FAA now plans to replace existing consoles on a one-to-one basis.
- Electronic charts, which present such information as airport layout maps and navigational maps, were to be generated by AAS' primary data-processing subsystem. With DSR and STARS, secondary subsystems will present mapping information to controllers.
- FAA eliminated the AAS requirement to play back flight tracking data at ten times the speed in which they were recorded. This requirement would have allowed FAA to reconstruct events more quickly for accident investigation and training purposes. With DSR and STARS, FAA will provide only a actual-time playback capability for flight track data.

Delays Have Led to Costly Interim Projects

Problems with AAS and the added time needed to develop follow-on automation projects have delayed replacement of FAA's aging equipment. We compared the milestones established in the 1988 AAS contract and the preliminary estimates established in 1994 when the automation program was restructured with the current schedule for the major components of FAA's automation program. If the 1988 milestones are used as a basis for comparison, the estimated schedules for all components of the program (excluding the cancelled tower component) have slipped substantially—from a minimum of 3.5 years to as much as 8 years. (The extent of these delays by segment are detailed in app. II.)

The schedule delays have caused FAA to add four interim projects—costing about $655 million—to sustain and enhance current automated air traffic

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[5]Flight strips provide controllers with basic status information, such as aircraft routes, altitudes, and air traffic clearances. Controllers mark up the paper strips to record changes in status. Each strip provides information on one flight.

control equipment. Three of the interim projects were designed for the TRACONS and one for the en route centers.

- The Interim Support Plan cost about $400 million; this project was initiated in 1987 and completed in 1997. For 60 large TRACONS, the Interim Support Plan provided, among other things, increased data-processing capacity, new displays, and new software that alerts controllers of potential conflicts between aircraft.
- The Automated Radar Terminal System (ARTS) IIIE Upgrade began in 1992 and has cost about $85 million as of January 1998. This project is upgrading data-processing equipment so that four of the largest TRACONS can handle an increasing volume of traffic. To date, two of the four system upgrades are complete. FAA expects that the remaining two will be completed by September 1998.
- In 1997, the agency began a third project—called Common ARTS—that is expected to cost $110 million to upgrade and sustain current hardware and software at 120 small TRACONS and at five of the largest ones. The agency expects to complete this project in April 2000.
- FAA's only interim project for en route centers is termed the Display Complex Channel Rehost. It transfers existing software from obsolete display channel computers to new, more reliable and maintainable computers at five centers. The project was completed in 1997 at a cost of $60 million.[6]

Restructured Program Meeting Some Cost and Schedule Goals but Not Others

FAA has had mixed results in pursuing the two major ongoing acquisitions in its restructured automation program. While the Display System Replacement acquisition for en route centers has been progressing as planned, the Standard Terminal Automation Replacement System acquisition for the TRACONS has experienced cost growth and schedule delays.

Display System Replacement

The DSR project will modernize equipment at en route centers by replacing 20- to 30-year-old display channels, controller workstations, and network infrastructure. FAA estimates the cost for this project to be $1.9 billion, including $1.0 billion for facilities and equipment and $900 million for operations and maintenance. Equipment is scheduled to become operational at the first of 20 sites in October 1998 and at the last site in May 2000.

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[6]See GAO report on the Display Complex Channel Rehost project: Air Traffic Control: Good Progress on Interim Replacement for Outage-Plagued Systems, But Risks Can Be Further Reduced (GAO/AIMD-97-2, Oct. 17, 1996).

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At this time, FAA does not consider any changes in the DSR project cost baseline to be necessary.[7] In terms of schedule, FAA expects to achieve the milestone for making DSR equipment operational at the first site—the Seattle en route center—later this year. The agency's Operational Test and Evaluation was completed in July 1997. Although "program trouble reports" were generated during testing, the contractor and FAA worked together to close or resolve all significant trouble (Type I and II) reports.[8] On January 16, 1998, the government formally accepted DSR for the Seattle center. While additional on-site testing is planned and updated software releases are to be incorporated in the Seattle center's equipment, our review disclosed no reason to question the achievability of FAA's schedule for DSR.

Standard Terminal Automation Replacement System

The STARS project will modernize the TRACONS by replacing the Automated Radar Terminal System (ARTS), which is composed of 15- to 25-year-old controller workstations and supporting equipment. The STARS' baseline cost estimate is $2.23 billion, including $940 million for facilities and equipment and $1.29 billion for operations and maintenance. The project's baseline schedule calls for equipment to become operational at the first of 171 sites in December 1998 and at the last site in February 2005.

FAA's STARS plan calls for the agency to operate an initial systems capability at 3 sites in the first phase and a full system capability at all 171 sites in the second phase. The initial capability is designed to provide the same functions as the current ARTS equipment, and the full capability, which is scheduled for installation beginning in January 2000, would include enhanced functions, such as allowing controllers to more precisely land aircraft on converging runways. Another phase was introduced in October 1997 when FAA decided to also make an early display configuration operational at Ronald Reagan Washington National Airport by September 1998. With the early display configuration, air traffic controllers will use the new STARS workstations. Existing ARTS software and STARS emergency service software will support the workstations.

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[7]When FAA management establishes an acquisition program, it approves performance and benefit objectives that are to be achieved within strict cost and schedule parameters, as defined in its Acquisition Program Baseline.

[8]Program trouble reports (PTR) are generated to document any discrepancies or anomalies encountered during testing. Each report is assigned a priority level to indicate its severity and impact on the system's operational effectiveness and suitability. Type I PTRs describe a problem that affects the performance of a critical function of the ATC system. Type II PTRs describe a problem that does not preclude the primary mission objective of controlling aircraft but does have an unsatisfactory impact on key support functions.

FAA is now facing difficulties in maintaining the STARS cost baseline. Costs are increasing because of such unexpected factors as the need for additional resources to maintain the program schedule, the deployment of the early display configuration, and the potential impact of design changes that air traffic controllers called for after reviewing the equipment. These unexpected factors have led the STARS program office to seek an additional $29 million in reprogrammed fiscal year 1998 facilities and equipment funds.

Regarding the STARS schedule, we believe that FAA cannot achieve its goal of making the first STARS operational in the Boston TRACON by December 1998, and a delay of 6 months or more is likely. One reason is that the software development effort for the initial systems capability—scheduled for completion by September 1997 but not completed until February 20, 1998—has proven to be problematic.[9] In a report to the Senate Aviation Subcommittee in January 1998, we cited several reasons for the delays.[10] First, the estimated size of the software development effort, measured in source lines of code, was 50 percent larger as of February 1998 than the original November 1996 estimate. Second, Raytheon's actual software production rates were much lower than projected, in part, because Raytheon was slow in staffing the project and the staff needed time to learn how to use a new corporate software development tool. In May 1997, Raytheon revised the software productivity goal from 240 to 180 lines of code per labor-month. Still, as of February 1998, Raytheon's data show that software productivity averaged 130 lines of code per labor-month. Third, there could be a need to further develop the software to resolve air traffic controllers' dissatisfaction with the STARS' design. After reviewing the equipment, controllers identified 98 concerns about how controllers work with the computers, such as how a pull-down menu on the display obscures their view of aircraft position data.

The December 1998 milestone is unrealistic not only because software development has run into difficulties but also because FAA and the contractor lack sufficient time to perform needed testing. Experience has shown that concern for meeting a schedule at the expense of a disciplined approach to developing systems and careful and thorough testing of them is imprudent and unproductive. As discussed below, the agency's test plan,

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[9]We reported a year ago that STARS' implementation—particularly at the three facilities targeted for operating it before fiscal year 2000—will likely be delayed if FAA and its contractor (Raytheon) experience difficulties in software development. See Air Traffic Control: Status of FAA's Standard Terminal Automation Replacement System Project (GAO/RCED-97-51, Mar. 5, 1997).

[10]Air Traffic Control: Timely Completion of FAA's Standard Terminal Automation Replacement System Software Is at Risk (GAO/AIMD-98-41R, Jan. 23, 1998).

approved on October 10, 1997, made key assumptions that are no longer valid.

- The test plan assumed that STARS' development would occur in two phases. Introduction of the third phase—the early display configuration—creates additional testing requirements that will consume staff time and effort.
- The test plan assumed that the System Readiness Demonstration, one component of Developmental Test and Evaluation, for the initial system capability would begin by mid-December 1997. Before starting the demonstration, FAA requires the closure or resolution of all significant program trouble reports. However, as of January 20, 1998, the early display configuration had 80 trouble reports outstanding and the initial systems capability had 213. A significant amount of additional work will be needed to close or resolve these trouble reports so the demonstration can commence. Also, FAA now intends to focus its resources on the early display configuration and defer testing of STARS' initial system capability.

A comparison of the schedules for DSR and STARS shows how aggressive and unrealistic the one is for STARS. The milestone for DSR to become operational at its first site is October 1998 and STARS' comparable milestone is December 1998. However, while Operational Test and Evaluation for DSR was completed in July 1997, it is still at least several months away for STARS.

As acquisition projects mature and more accurate estimates of cost, schedule, performance, and benefits become available, FAA's acquisition policy calls for the project offices to seek approval from the Joint Resources Council—a group of senior FAA management offficials—for any needed baseline changes. FAA has not revised the STARS cost and schedule baselines to recognize expected controller-requested design changes, the delays and problems associated with the ongoing software development effort, the introduction of the early display configuration phase, and pressures on the testing schedule. With revised baselines, the agency would reflect the true status of the STARS project, better define its funding needs by year, provide sufficient time and resources for disciplined and thorough testing, and avoid spending funds unnecessarily to get sites ready before the new STARS equipment can be delivered for installation. According to the Deputy Integrated Product Team Leader for Terminal Air Trafffic Systems Development, FAA is holding off reconsideration of the cost and schedule baselines until the controllers and system developers agree on needed design changes.

Mr. Chairman, this concludes my prepared statement. We will be happy to respond to any questions that you or other Members of the Subcommittee may have.

Advanced Automation System (AAS) Project Funds Expended and Transferable to Restructured Automation Program

FAA's investment analysis group estimates that the agency spent about $2.6 billion on the AAS project through May 1994. Based on our prior work and interviews with agency officials, we determined that the restructured program was able to salvage about $1.1 billion in AAS-developed laboratory facilities and computer hardware and software. The balance—about $1.5 billion—was wasted because the remaining equipment and work did not contribute to follow-on projects. The following chart details our analysis.

Dollars in millions

	Funds expended	Funds transferable	Explanation for transferable amounts
Design phase	$277	$0	Design phase did not produce any AAS hardware or software that was transferable to the acquisition phase.
Prime contract			
PAMRI	46	46	FAA completed this segment.
ISSS	1006	412	Forty-one percent of capitalized project costs—hardware and software—was transferable to DSR.[a]
TAAS	317	0	Project was cancelled.
TCCC	160	0	Project was cancelled.
ACCC	19	0	Project was cancelled.
Laboratory facilities	26	26	Funds were used to expand FAA's Technical Center test laboratory and to create a development and display facility for conducting early user evaluations.
Advanced en route automation (AERA)	48	42	Most of the AERA effort led to MITRE's development of a conflict probe capability that is being tested at two en route centers.
Support contracts	259	106	ISSS was the major thrust of AAS work. Because 41 percent of ISSS' capitalized cost was transferable to DSR, we credited the restructured program with 41 percent of this cost.

(continued)

Dollars in millions

	Funds expended	Funds transferable	Explanation for transferable amounts
Implementation support	110	83	The current program benefited from $62 million for site preparation work and $21 million for testing transferable ISSS software.
Training	4	0	Only PAMRI—the least complex segment of AAS—was implemented.
En route center modernization	377	377	En route center modernization was needed.
Total	**$2,649**	**$1,092**	

aFAA determined that 44 percent of ISSS costs (i.e., hardware and software) were capitalized. However, we believe that 41 percent is a more appropriate capitalization because FAA included costs for laboratory expansion, and we treated this as a separate line item.

Note: AAS expenditures listed here do not include FAA's personnel costs. FAA officials estimated that FAA had about 100 employees assigned to the AAS project at any given time.

Changes in Implementation Milestones for Automation Program

Component of AAS/ restructured program	Field site	1988 AAS contract	1994 Restructured program	1998 Program estimate
ISSS/DSR	first	Jan. 1994	Sep. 1998	Oct. 1998
	last	Oct. 1995	Jan. 2000	May 2000
TAAS/STARS	first	Jun. 1995	Dec. 1998	Dec. 1998
	last	Mar. 1997	Dec. 2003	Feb. 2005
TCCC/tower automation	first	Jun. 1995	Apr. 1997	cancelled in Feb. 1997
	last	Jul. 1999	Dec. 2000	cancelled in Feb. 1997
ACCC/Host replacement	first	Jul. 1996	2002	2004
	last	Jun. 1998	2003	2005

Note: DSR's milestones were compared to those of the scaled back Initial Sector Suite System (ISSS) segment of AAS. STARS' milestones were compared to those of the cancelled Terminal Advanced Automation System (TAAS) segment. The Tower Control Computer Complex (TCCC) segment of AAS was cancelled and ultimately not replaced. The schedule for Host replacement was compared to the cancelled Area Control Computer Complex (ACCC) segment of AAS.